



Early to Middle Holocene subsistence strategies in the Pampas region: Evidence from the Arroyo Seco 2 site



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ABSTRACT

The following paper presents an analysis of the faunal material from the Arroyo Seco 2 site dated from the Early to Middle Holocene (ca. 8500 to 5800 ¹⁴C yrs B.P.). The zooarchaeological and taphonomic data presented here provides significant information for understanding the dynamics of multiple occupations at the site, as well as the transition in prey choice for Pampean hunter-gatherers during this time period; from megamammals to large and finally medium sized prey. The Arroyo Seco 2 site contains four different fauna dated to Early and Middle Holocene, including *Eutatus seguini*, *Lama guanicoe*, *Ozotoceros bezoarticus*, and *Rhea americana*. The archaeological record from the Arroyo Seco 2 site shows that hunter-gatherers gradually shifted their generalist diet from extinct mega and large sized mammals during the Late Pleistocene to medium sized prey during the Early to Middle Holocene.

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1. Introduction

During the Late Pleistocene-Early Holocene transition (ca. 10,000 ¹⁴C yrs B.P. or 11,700 cal yrs B.P., Walker et al., 2012) in the Pampas region of Argentina, hunter-gatherer subsistence strategy is classified as a generalized regional economy; in other words, hunting and scavenging a variety of different sized mammals (Gutiérrez and Martínez, 2008; Martínez et al., 2016; Mazzanti and Quintana, 2001; Miotti and Salemme, 1999; Salemme and Miotti, 2008; Yacobaccio, 2013). This range of mammals included megamammals such as *Megatherium americana* (ca. 6000 kg) and *Glossotherium robustum* (ca. 1700 kg), large sized mammals such as *Equus neogeus* (ca. 300 kg) and Camelidae cf. *Hemiauchenia* (ca. 300 kg), and medium sized mammals such as guanaco (*Lama guanicoe*; ca. 90 kg) and pampas deer (*Ozotoceros bezoarticus*; ca. 30 kg). The mega and large sized mammals were high-ranked prey for the early hunter-gatherers (Charnov, 1976; Haynes, 2002; Stephens and Krebs, 1986). They proportioned at least five types of resources, including abundant meat, tendons, fat, marrow, and as a raw material for the confection of bone artifacts and fuel (Johnson, 2007). With the mass extinction of the Late Pleistocene, South America witnessed almost all megamammals and most of the large sized mammals become extinct (Cione et al., 2009). Both

taxonomic diversity and richness were greatly reduced. Hunting was reserved to the few remaining large extinct taxa and to medium and small sized prey. Artiodactyls, such as the guanaco, pampas deer, and the flightless bird ñandú (*Rhea americana*, ca. 35 kg) where now the main subsistence for terrestrial meat in the Pampas region. The hunter-gatherer subsistence strategy eventually shifted to a specialized regional economy during the Middle Holocene, based principally in the hunting of guanaco (Gutiérrez and Martínez, 2008; Martínez and Gutiérrez, 2004; Miotti and Salemme, 1999).

There are few sites which clearly demonstrate this shift in subsistence as well as the Arroyo Seco 2 site (AS2). Here, at least three megamammals (*Megatherium americana*, *Toxodon plantensis* and *Lestodontinae* cf. *Lestodon*) and three extinct large sized mammals (*Equus neogeus*, *Hippidion* sp. and Camelidae cf. *Hemiauchenia*) are dated between ca. 12,170 and 9775 ¹⁴C yrs B.P. During the Early Holocene, one extinct large sized mammal (*Eutatus seguini*) and three extant medium sized taxa (guanaco, pampas deer and ñandú) are dated between ca. 8500 and 7400 ¹⁴C yrs B.P. Finally, during the Middle Holocene, ca. 7400 ¹⁴C yrs B.P. (8200 cal yrs B.P.) to 3800 ¹⁴C yrs B.P. (4200 cal yrs B.P., Walker et al., 2012), guanaco is dated to 5800 ¹⁴C yrs B.P. The shift from megamammals, to large, and lastly to medium sized mammals was the consequence of variable processes, including fluctuating climatic conditions, abundance of animal resources, and hunter-gatherer prey choice. The following paper examines the AS2 faunal assemblage, using the results from the zooarchaeological and taphonomic data to discuss the sites formation processes and hunter-

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gatherer subsistence strategies, as well as general trends in subsistence models at a regional scale during the Early to Middle Holocene.

2. Background

2.1. The Pampas region

With flat to gentle undulating landscapes, the Pampas region is a large ecosystem of grasslands found primarily in Argentina and Uruguay. There are four eco-regions, including the Uruguayan Savanna, the Humid Pampas, the Espinal, and the Low Monte (these last two are also called the Dry Pampas) (Mancini et al., 2005) (Fig. 1). Palaeo-environmental studies suggest that after the dry and probably cold conditions of the Late Pleistocene (Cione et al., 2003; Quattrocchio et al., 2008; Zárate and Blasi, 1991), the Holocene transition is characterized by a more humid environment, which eventually returned to stable arid conditions during the Early Holocene (Bonadonna et al., 1999; Grill et al., 2007; Iriondo et al., 2009; Muhs and Zárate, 2001; Prado and Alberdi, 1999; Prieto, 2000; Quattrocchio et al., 2008; Tonni et al., 1999; Zárate et al., 1998). These periods of climate change, from cold arid to warmer humid conditions, combined with the initial presence of hunter-gatherers; resulted in the extinction of megamammals and most large sized mammals (Barnosky and Lindsey, 2010; Cooper et al., 2015; Lima-Ribeiro et al., 2013; Metcalf et al., 2016; Prado et al., 2015; Villavicencio et al., 2016). A final shift in climate during the Early to Middle Holocene, a warm period (Hypsithermal) which lasted from ca. 8000 to 4500 ^{14}C yrs B.P., brought with it more humid conditions accompanied by marine ingression (Aguirre and Whatley, 1995; Iriondo et al., 2009; Mancini et al., 2005; Prieto et al., 2004; Quattrocchio et al., 2008; Tonni et al., 1999). Finally, by the end of the Middle Holocene, stable arid conditions returned to the Pampas region (Mancini et al., 2005; Prieto, 1996; Zárate et al., 2000).

There are currently twelve archaeological sites from the Pampas region dated between ca. 12,200 and 7400 ^{14}C yrs B.P.; four contain megamammals (>1000 kg), eight contain large sized mammals

(between 100 and 1000 kg), and all twelve sites contain medium sized mammals (between 25 and 100 kg) (Supplementary Table 1). Some megamammals, specifically herbivore species of xenarthrans, appear to have survived well into the Early Holocene in at least two sites (Gutiérrez et al., 2010; Politis and Messineo, 2008). Relative to other areas of the world, this suggests that the decline of larger body sized mammals was delayed in the Pampas region (Cooper et al., 2015; Mann et al., 2015; Nogués-Bravo et al., 2010). Availability of these few remaining extinct mega and large sized mammals was likely minimal and regionally focused, as hunter-gatherers were now directing their subsistence strategies towards medium sized prey (Martínez et al., 2016). Of the twelve archaeology sites dated from the Late Pleistocene to Early Holocene, 4 contain direct dates on medium sized taxa: La Olla, El Guanaco 1 and 2, and Arroyo Seco 2. The El Guanaco locality, situated 11 km from the Atlantic coast (Bayón et al., 2004), contains dates from both guanaco (ca. 9250 to 8400 ^{14}C yrs B.P.) and ñandú (ca. 9100 ^{14}C yrs B.P.). The La Olla locality, set in a semidiurnal mesotidal beach environment (Blasi et al., 2013), contains dates from sea lion (*Otariidae* sp.) (ca. 7400 to 6600 ^{14}C yrs B.P.), guanaco (ca. 6960 ^{14}C yrs B.P.), as well as wood and plant fragments (Bayón and Politis, 2014). Only the Arroyo Seco 2 site, located 60 km northeast of the Atlantic coast, contains direct dates from both megamammals and large mammals during the Late Pleistocene-Early Holocene transition, and dates from medium sized taxa during the Early Holocene.

For the Middle Holocene, population dynamics (Barrientos and Perez, 2005; Martínez, 1999; Politis, 1984) and a bias in archaeological survey and site formation processes (Favier-Dubois, 2006) have reduced site visibility. There are five sites in the inter-sierra Pampas (between the Tandilia and Ventana hill ranges) dated to the Middle Holocene (Supplementary Table 1). These sites contain evidence for the exploitation of different taxa, including guanaco, pampas deer, armadillos, ñandú, and sea lion (Bonomo et al., 2013; Martínez and Gutiérrez, 2004; Mazzanti and Quintana, 2001; Miotti and Salemme, 1999; Politis and Madrid, 2001). While the regional subsistence is classified as a “specialized economic strategy” in guanaco (Martínez and

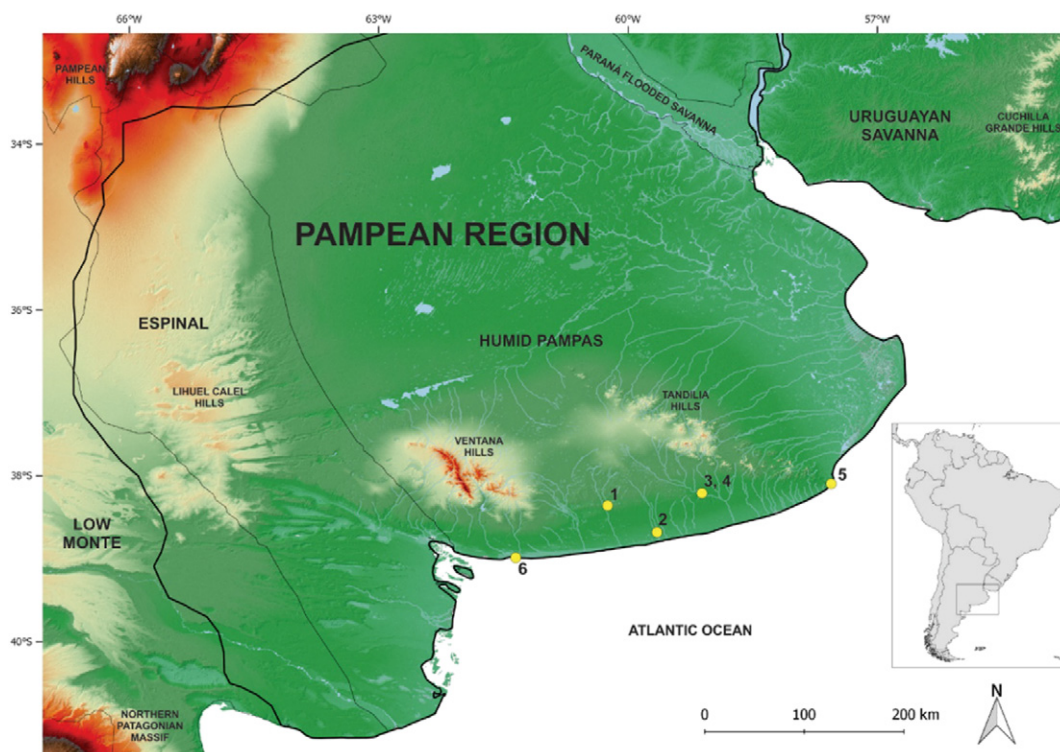


Fig. 1. Map of the Pampean region showing ecological geo-regions and the location of sites mentioned in the text. (1) Arroyo Seco 2; (2) El Guanaco 1 and 2; (3, 4) Paso Otero 4, Paso Otero 5; (5) Alfar; (6) La Olla.

Gutiérrez, 2004; Miotti and Salemme, 1999); Middle Holocene sites like Alfár, located in the coastal dunes (Fig. 1), suggest sea lion as a main resource and guanaco as a complementary prey (Bonomo and León, 2010). For the Arroyo Seco 2 site, there is a unique record of human activity during the Middle Holocene. Evidence of guanaco processing is dated in ca. 5800 ¹⁴C yrs B.P., and the site has one of the best records of inhumation for the period (Politis et al., 2014a, Politis et al., 2009).

2.2. The Arroyo Seco 2 site

The Arroyo Seco 2 site is located in the inter-sierra grasslands of the Pampas region (Fig. 1). It is a stratified open-air site situated on a low-lying knoll between a small temporary lake and a shallow creek. The site is one of three in the locality, and was discovered and test pitted by archaeology amateurs from the city of Tres Arroyos in the early 1940s (Politis, 2014). From 1979 to the most recent excavations in 2015, a total of 314 m² has been excavated.

The archaeological material encompasses successive episodes of occupations from the Late Pleistocene to early post-Hispanic times (occupation from ca. 12,170 ¹⁴C yrs B.P. to the 19th century), with low stratigraphic resolution (Fidalgo et al., 1986; Politis et al., 2016, Politis et al., 2014b). There are currently 64 radiocarbon dates from the site, which include 29 dates on extinct fauna (ca. 12,240 to 7388 ¹⁴C yrs B.P.), 7 dates on extant fauna (ca. 8461 to 5793 ¹⁴C yrs B.P.), 24 dates on human skeletons (ca. 7805 to 4487 ¹⁴C yrs B.P.), 3 dates on pedogenic carbonates (ca. 5740 to 1890 ¹⁴C yrs B.P.), and 1 date on a Late Holocene paleosol from the banks of the Tres Arroyos creek (1140 ± 60 ¹⁴C yrs B.P.). The extensive chronological dimension in a relatively short stratigraphic sequence (~2 m) of loessial sediments has been one of the main causes for the sites low archaeological resolution. The sedimentary sequence is made up of four units, defined from the base to the top of the profile as Z, S, Y, and X, each one representing aeolian episodes separated by discontinuities (Fidalgo et al., 1986; Gentile, 2014; Politis et al., 2016). The aeolian episodes Z and S likely occurred during the Late Pleistocene-Early Holocene, followed by the accumulation of aeolian episode Y during much of the Early Holocene. The highest frequency of lithic artifacts and fauna material was recovered from the Unit Y. Finally, the Unit X is related to arid climate deposits of the Late Holocene (Politis et al., 2016).

The AS2 site contains 40 taxonomic classifications (MNI = 74) (Gutiérrez, 2004; Rafuse, 2013; Salemme, 2014); numerous types of flakes and stone tools (Leipus, 2006; Leipus and Landini, 2014); and 38 human burials (50 individuals of different ages and sex) which occur as both primary and secondary single-individual and multi-individual adults and infants (Barrientos, 1997; Politis et al., 2014a). The burials date to the later part of the Early and Middle Holocene (7805 ± 85 and 4487 ± 45 ¹⁴C yrs B.P.; n = 25 dates). Considering broad taxonomic categories, the fauna with the highest NISP% are artiodactyls (40%), followed by rodents (17%), and extinct mammals (5%) (Rafuse, 2013; Salemme, 2014). A total of 12 extinct taxonomic categories have been assigned; which includes five ranked at the level of species: *Equus neogeus*, *Eutatus seguini*, *Glossotherium robustum*, *Megatherium americanum* and *Toxodon platensis*; four ranked at the level of genus: *Glyptodon* sp., *Hippidion* sp., *Macrauchenia* sp. and *Myiodon* sp.; two ranked at the level of family: Camelidae cf. Hemiauchenia and Equidae; and one ranked at the level of subfamily: Lestodontinae cf. Lestondon.

Based on the distinct lines of evidence, the site represents one of the oldest human occupations in the Americas (Madsen, 2015; Politis et al., 2016). Its earliest cultural episode dates to 12,170 ¹⁴C yrs B.P. (13,975–14,152 cal yrs B.P.) from both *Megatherium americanum* and *Equus neogeus* bone remains. There are also dates on *Toxodon platensis* in ca. 11,750 ¹⁴C yrs B.P. (13,473–13,594 cal yrs B.P.) and *Equus neogeus* and *Hippidion* sp. in ca. 11,182 ¹⁴C yrs B.P. (13,035–13,100 cal yrs B.P.). Evidence for human activity at the site includes the association of a uniface lithic assemblage, the selective representation of appendicular skeletal

elements, the marrow extraction and/or bone quarrying of bone elements, and the open-air setting which is considered inconsistent with the natural accumulation of such a diversity of mammals (Politis et al., 2016).

3. Materials and methods

Taxonomic abundance was quantified using the standard measurements NISP -number of identified specimens- (Payne, 1975) and MNI -minimum numbers of individuals- (White, 1953). Anatomical representation for each taxa was quantified using MNE -minimum number of elements- (Binford, 1984, Binford, 1978, Lyman, 1994a, 1994b) and MAU -minimum number of animal units- (Binford, 1984, Binford, 1981, Binford, 1978). The anatomical representation was calculated by separately considering fused, unfused, and undetermined fusion. The long bones were quantified using three portions: proximal epiphysis, diaphysis, and distal epiphysis. For the determination of age classes in the guanaco sample, the skeletal fusion and dental development proposed by Kaufmann (2009) was considered. To evaluate the representation of *Lama guanicoe* in relation to the bone mineral density (BMD), the density index of Camelidae elaborated by Elkin (1995) was used.

In order to correctly evaluate and enhance information of the fossil record (sensu Behrensmeier et al., 2000; Lyman, 2010), the following taphonomic variables were identified: weathering stages (Behrensmeier, 1978), location of sedimentary abrasion (Gutiérrez and Kaufmann, 2007), carnivore marks -punctures, pitting, scoring, furrowing, crenulated edge, and scooping out- (Binford, 1981; Haynes, 1980), surface percentage and type of calcium carbonate -light and dense coating- (Lyman, 1994a), presence/absence of trampling (Domínguez-Rodrigo et al., 2009), burning stage of thermal alteration -scorched, carbonized, and calcined- (White, 1992), and surface percentage of rodent marks (Johnson, 1985; Shipman, 1981), root etching (Andrews, 1990), manganese staining (López-González et al., 2006), and chemical deterioration (Gutiérrez and Johnson, 2014). The identification of anthropic modifications included cut marks (Fisher, 1995), thermal alteration, and bone fractures (Blumenschine et al., 1996; Galán et al., 2009; Johnson, 1985; Olsen and Shipman, 1988). Bone fractures were classified as dry, fresh, and anthropic (Johnson, 1985). Fresh fractures were considered bones which were broken while green but lack technological features such as impact marks (Blumenschine and Selvaggio, 1988).

Quantification of taxonomic abundance and taphonomic modifications were made irrespective of the stratigraphy and horizontal distribution. The entire AS2 site represents a type of cumulative palimpsest (Bailey, 2007; Politis et al., 2016), and separation of the Early to Middle Holocene faunal material in stratigraphic units can bias the results. Therefore, all faunal remains from the four loess units were treated as one assemblage.

4. Results

4.1. Radiocarbon dates

The Early to Middle Holocene fauna dates are from four distinct species and seven bone elements (Table 1). The Early Holocene dates correspond to one extinct mammal, *Eutatus seguini*: a vertebra (7388 ± 74 ¹⁴C yrs B.P., AA-90117); and three extant mammals, *Lama guanicoe*: a radius-ulna (8461 ± 74 ¹⁴C yrs B.P., AA-90120) and two midshaft long bone fragments (8390 ± 410 ¹⁴C yrs B.P., AA-52613, and 7540 ± 80 ¹⁴C yrs B.P., AA-24052); *Ozotoceros bezoarticus*: a humerus (7836 ± 69 ¹⁴C yrs B.P., AA-106016); and *Rhea americana*: a tibia (7747 ± 56 ¹⁴C yrs B.P., AA-106015). A tooth from Camelidae cf. Hemiauchenia was also dated to 9775 ± 45 ¹⁴C yrs B.P. (Prado et al., 2015). This specimen is not included here because it was discussed in detail as part of the Late Pleistocene assemblage (see Politis et al., 2016). The Middle Holocene dates correspond to guanaco: a femur (5793 ± 64 yrs B.P., AA-

Table 1
Holocene dates from the Arroyo Seco 2 faunal assemblage.

Specimen	¹⁴ C age B.P.	±	δ ¹³ C value	F(δ ¹³ C)	±F(δ ¹³ C)	Chemical fraction dated	Lab. code	Bone element	Reference
<i>Eutatus seguini</i>	7388	74	−19.7	0.3986	0.0037	Collagen	AA-90117	Lumbar vertebra	Politis et al. (2014b)
<i>Lama guanicoe</i>	8461	74	−20.0	0.3488	0.0032	Collagen	AA-90120	Radial-ulna	Politis et al. (2014b)
<i>Lama guanicoe</i>	8390	410	−23.3			Collagen	AA-52613	Long bone	Politis et al. (2014b)
<i>Lama guanicoe</i>	7540	80	−19.8			Collagen	AA-24052	Long bone	Politis et al. (2014b)
<i>Lama guanicoe</i>	5793	64	−19.4	0.4862	0.0039	Collagen	AA-90119	Femur	Politis et al. (2014b)
<i>Ozotoceros bezoarticus</i>	7836	69	−20.9	0.377	0.0032	Collagen	AA-106016	Humerus	This publication
<i>Rhea americana</i>	7747	56	−21.8	0.3812	0.0027	Collagen	AA-106015	Tibia	This publication

90119); and a Canidae tooth (not shown Table 1) recovered with human burial N°11 (AS18) and dated 6495 ± 65 ¹⁴C yrs B.P. The canine teeth are commonly found in the AS2 burials as a type of grave good, with a single perforation at the root (Laporte, 2014). This specimen is not included here because the bone corresponds to a type of burial good and is not representative of subsistence.

4.2. Skeletal representation

The total NISP for guanaco is 1164 specimens (Table 2). All skeletal parts of guanaco are present in the assemblage. The most abundant anatomical units correspond to metapodials, phalanges, astragalus, humerus, calcaneus, and smaller carpal and tarsal bones (Fig. 2). A MNI = 20 was calculated using the left astragalus (Supplementary Table 2). In general, the appendicular skeleton (MNE = 813; 85%) is better represented than the axial (MNE = 143; 15%); not including the teeth which were independently quantified. Taking into consideration a selected group of elements (humerus, radius, ulna, tibia and femur) with evidence of early and late fusion (sensu Kaufmann, 2009); the proportion of unfused, early fused, and late fused elements suggests 23.5% of the guanaco specimens correspond to newborn, 26.5% to juveniles and subadult, and 50% to adults and older individuals. Because of the high fragmentation of the teeth sample, just one individual (MNI = 1) was quantified corresponding to a juvenile, and one individual (MNI = 1) corresponding to an adult. When the skeletal part profile of guanaco (MAU%) is correlated with the bone mineral density (BMD) index proposed by Elkin (1995) for camelids, a positive and significant result is obtained ($r_s = 0.62822$; $p = 0.00020154$). As a result, the over representation of some of the appendicular skeleton, such as the humerus shaft and metapodial distal condyles; as well as the under representation of the axial skeleton, appears to be related to bone-density.

The total NISP for pampas deer is 159 specimens (Table 2). The pampas deer is the second most represented species in the site in terms of number of individuals (MNI = 8) -calculated here with the left astragalus-. Similar to the guanaco, the anatomical representation of the pampas deer is unequal (Supplementary Table 3). The appendicular skeleton (MNE = 104; 87%) is more abundant than the axial (MNE = 16; 13%; isolated teeth were not included) (Fig. 2). Several anatomical parts of the pampas deer are absent, such as the cervical vertebrae, the sacrum, and the calcaneus. No skull and jaw bones were identified but 10 complete teeth and a fragment of antler was recovered. In reference to the long bones, the most abundant segments correspond to the distal epiphyses of the humerus and the metapodials. The tibia is the only element with all three segments. The greater abundance in the assemblage of some of the denser anatomical segments, such as the distal humerus, suggests that bone density may be responsible for the pampas deer sample. Regarding the age determination in the pampas deer, several unfused elements were identified and at least two of the eight individuals are immature.

The most abundant species of bird in the AS2 assemblage is ñandú (NISP = 21; MNI = 1). Other birds identified at the site include *Nothura maculosa* (NISP = 2) and *Speotyto cunicularia* (NISP = 3). There is a greater abundance of the appendicular skeletal elements of ñandú (Table 2, and Fig. 2). The most common anatomical parts correspond

Table 2
NISP count of Early to Middle Holocene taxa at Arroyo Seco 2.

Anatomical unit	<i>Lama guanicoe</i>	<i>Ozotoceros bezoarticus</i>	<i>Rhea americana</i>	<i>Eutatus seguini</i>
Carpal/Tarsal indet.	29	4		
Astragalus	40	16		
Atlas	5			
Axis	1			
Bezoar	4			
Capitulum		5		
Calcaneus	29	1		
Rib	11	11		
Antlers		1		
Skull	28			
Cuboid	38			
Ulna		1		
Cuneiform	22	1		
Teeth	43	7		
Ectocuneiform	23			
Scaphoid	31	3		
Scapula	7	2		
Sternebra	1			
Phalanx indet.	17	3	2	
Phalanx 1st	93	6		
Phalanx 2nd	49	1	5	
Phalanx 3rd	13		2	
Phalanx 5th			2	
Femur	49	8		
Fibular	13			
Fragment indet.	22	8		
Long bone indet.	104	2		
Pyramidal		1		
Humerus	46	9		1
Lunar	6	1		
Magnum	17	1		
Mandible	4	1		
Maxilla	2			
Metapodium indet.	108	17		
Metacarpal	12	1		
Metatarsal	8	1		
Tarsus-metatarsus			3	
Navicular	22	4		
Hemi-pelvis	15	7		
Pisiform	9			
Radio	3			
Radio-ulna	42	8		
Patella	5	2		
Sacrum	1			
Sesamoid	19			
Semilunar		5		
Tibia	31	6	4	
Trapezoid	20			
Unciform	25	2		
Vertebra indet.	41	7	1	
Caudal vertebra	6			
Cervical vertebra	13		1	
Lumbar vertebra	20	3		1
Thoracic vertebra	17	3	1	
Dermal scute				1
Egg shell			(781)	
Total NISP	1164	159	21	3

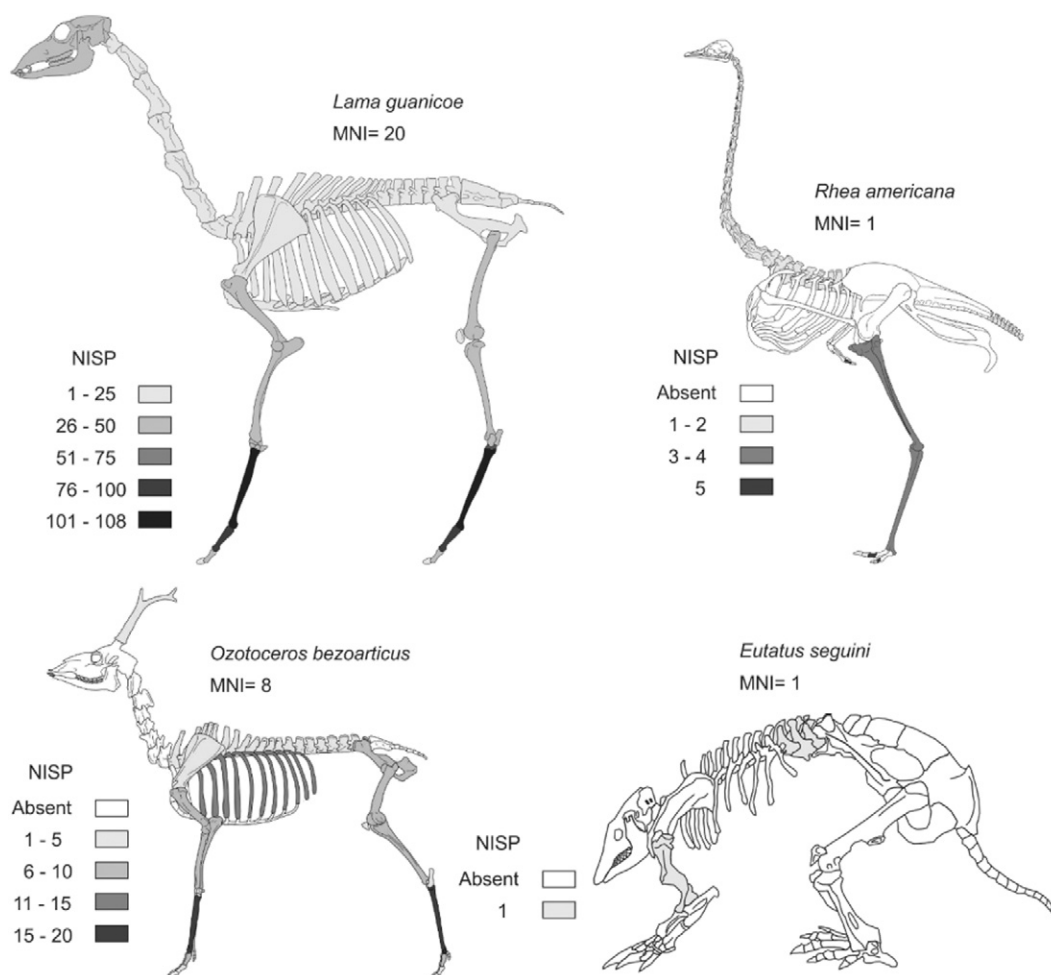


Fig. 2. Anatomical representation of the Early to Middle Holocene taxa at Arroyo Seco 2.

to phalanges, followed by the tibia-tarsal and tarsal-metatarsal. Numerous fragments of ñandú eggshell were also recovered ($n = 781$); 93% of which are <2 cm in diameter. Considering the physical characteristics of bird bone, differential preservation is likely responsible for the skeletal part representation of the ñandú assemblage (Behrensmeyer et al., 2003; Cruz, 2007); although the sample size is too small to measure this statistically.

The *Eutatus seguini* is the smallest of the extinct Pleistocene mammals in the AS2 site (~200 kg), and is represented by only three specimens (NISP = 3; MNI = 1): humerus, lumbar vertebra, and dermal scute. A second extinct mammal with dermal scutes recovered in the site is *Glyptodon* sp. (NISP = 4; 1 dermal scute; MNI = 1). Other smaller extant armadillos in the site include big hairy armadillo (*Chaetophractus villosus*) (NISP = 81; 50 dermal scutes) and pichi (*Zaedyus pichiy*) (NISP = 45; 40 dermal scutes) (Salemme, 2014). As seen here, the majority of the bone specimens from these small mammals are dermal scutes, however, processing marks were identified in one tibia from hairy armadillo. In addition to this modified specimen, numerous dermal scutes with thermal alteration were identified; but there is no clear evidence to indicate that this was the result of human induced burning.

In summary, the guanaco is the most abundant species in the site (MNI = 20). In addition to the guanaco, the only species with more than three individuals is the pampas deer (MNI = 8). The anatomical representation of these two species shows a clear difference in the representation of the appendicular and axial skeleton, the former being broadly more represented than the latter. Given the body size of the pampas deer, hunter-gatherers likely transported full carcasses. The

guanaco carcasses may also have been transported in totality; however, some individuals were possibly transported by anatomical units. Bone density estimates and natural formation processes provide evidence for the absence of anatomical units of this taxon. Differential bone preservation also affected the ñandú and *Eutatus seguini*. In order to better understand the dynamics of the natural formation processes responsible for the fragmentation of the bone assemblage, the following section will describe the taphonomic modifications identified at the site.

4.3. Taphonomy

The faunal assemblage at the Arroyo Seco 2 site shows evidence of several modifications (Table 3). The most significant modification is bone fragmentation (81%, $n = 1100$). This includes three categories of fractures: dry (64%, $n = 868$), anthropic (11%, $n = 152$), and fresh (6%, $n = 80$). Only 18% ($n = 247$) of the sample are complete bone.

The guanaco assemblage presents the entire range of fracture types: dry fractures (77%, $n = 745$), anthropic fractures (15%, $n = 144$), and fresh fractures (8%, $n = 75$). The bone element with the highest frequency of anthropic fractures in the guanaco assemblage is the humerus (21%; $n = 31$) (Fig. 3A). With respect to the technological features identified in guanaco, 15% ($n = 22$) contain impact points. The complete bone elements (17%, $n = 200$) include the carpus and tarsus bones (75% of this sample, $n = 147$), while the remaining 15% are phalanges, astragalus and calcaneus. The pampas deer assemblage contains 75% ($n = 120$) of the bones fractured. Like the guanaco, the carpus and tarsus represent the highest percentage of complete bone specimens (59%; $n = 23$), followed by the astragalus (26%, $n = 10$). Anthropic fractures

Table 3
Taphonomic modifications observed in the Arroyo Seco 2 assemblage.

Taphonomic modification	<i>Lama guanicoe</i>	<i>Ozotoceros bezoarticus</i>	<i>Rhea americana</i>	<i>Eutatus seguini</i>
Dry fractures	745	110	10	3
Fresh fractures	75	4	1	
Anthropic fractures	144	6	2	
Complete bone	200	39	8	
Weathering	216	33	3	1
Calcium carbonate	262	38	14	2
Chemical deterioration	372	28	4	
Root marks	266	25	3	2
Rodent marks	186	14	4	2
Manganese	307	31	6	
Geological abrasion	18	1		
Carnivore marks	69	6	3	
Thermal alteration	39	13		
Cut marks	22	2	1	

were identified in the pampas deer femur, humerus, tibia, radio-ulna and metapodial. The ñandú assemblage contains only two specimens with evidence of anthropic fractures (tibia-tarsal and tarsal-metatarsal). A fresh fractured bone from ñandú was also observed, but this specimen contains broad evidence of carnivore action as well, suggesting multiple processes (see discussion below) (Fig. 3D). Finally, the *Eutatus seguini* bones present all dry fractures.

Chemical deterioration is one of the most frequent modifications in the site, but also one of the most variable in terms of chemical or biochemical processes in the microenvironment that could be involved,

such as microorganisms and roots. This modification was identified in all the taxa apart from *Eutatus seguini*. The highest frequency was observed in guanaco (32%, $n = 372$), pampas deer (18%, $n = 28$) and ñandú (19%, $n = 4$) (Fig. 3B). These processes result in significant surface damage which can weaken the bone structure and eventually lead to fragmentation. The chemical deterioration acts on the cortical surface of the bone, causing surface damage and masking other taphonomic modifications (Gutiérrez and Johnson, 2014).

Two chemical deposits identified on the bones are calcium carbonate (CaCO_3) and manganese (Mn). All taxa presented CaCO_3 : ñandú (67%, $n = 14$); *Eutatus seguini* (67%, $n = 2$); pampas deer (24%, $n = 38$) and guanaco (22%, $n = 262$). Specimens were recorded with CaCO_3 contain both a light and dense coating. A dense deposit of CaCO_3 will favor the preservation of the bone by creating a protective layer around the surface; however, this dense deposit can mask other taphonomic modifications such as cut marks, and consequently underestimate the representation of other types of modifications in the faunal assemblage. Removal of CaCO_3 is very destructive, therefore only a small sample of guanaco specimens were chosen for cleaning ($n = 19$; 2% of the total sample of this species). The removal of CaCO_3 helped to identify different taphonomic modifications, including Mn deposit, root marks, rodent marks and weathering (Fig. 3C). The manganese staining in the AS2 site is likely the result wetter climate conditions and related to fluctuations in the paleo-water table during certain moments of stability in the landscape (Politis et al., 2016: 6). In reference to the Mn deposit in the remaining specimens, most of the assemblage contained only a light staining, including ñandú (28%, $n = 6$), guanaco (26%, $n = 307$) and pampas deer (19%, $n = 31$).

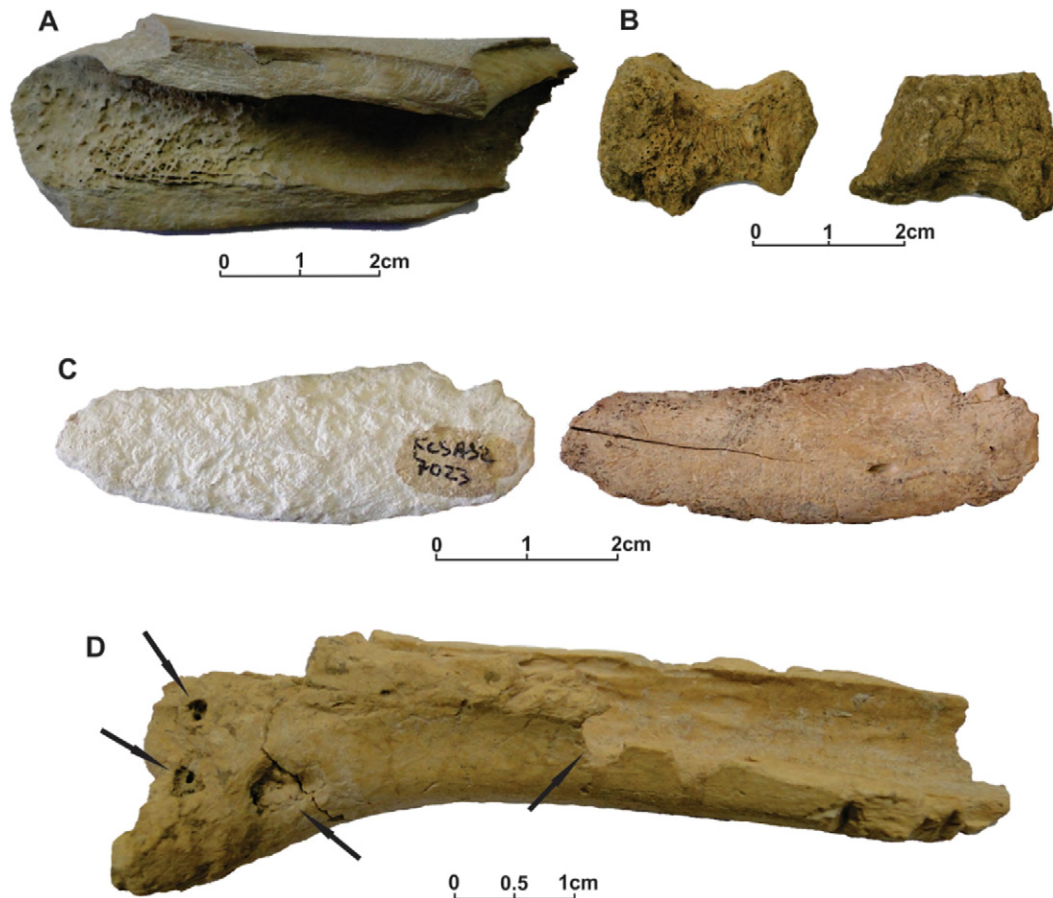


Fig. 3. Example of taphonomic modifications identified at the Arroyo Seco 2 site. (A) guanaco femur with anthropic fracture; (B) guanaco scaphoid (left) and indeterminate carpal or tarsus bone (right) with chemical deterioration; (C) guanaco specimen before and after the removal of the dense CaCO_3 deposit, note the now visible Mn deposit on the cleaned specimen; (D) ñandú tarsus-metatarsus with fresh fracture and multiple carnivore punctures.

Root etching was observed in all the taxa sampled. This process can strongly affect the cortical surface of bone; masking previous modifications (e.g., cut marks). Most of the specimens contained a low surface coverage (between 0 and 25%) but moderate to intense degrees of root etching (>25% of the bone surface) was observed in just a few specimens. In combination with other chemical and biochemical processes in the microenvironment, root action masks the identification of other modifications. The taxa with the highest percentage of root etching is *Eutatus seguini* (67%, $n = 2$), followed by guanaco (23%, $n = 266$), pampas deer (16%, $n = 25$) and ñandú (14%, $n = 3$).

The Pampas region contains several extant rodents. Small rodents identified at the AS2 site include mara (*Dolichotis patagonum*: NISP = 6; MNI = 2) and plains vizcacha (*Lagostomus maximus*: NISP = 36; MNI = 2). While both of these rodents present an important frequency of skeletal parts, there is minimal evidence to suggest they were being processed at the site. These species are capable of modifying the cortical surface of the bone and also the spatial displacement of material with their burrowing activities (Pelletier et al., 2016). The AS2 sample analyzed here contains rodent marks in *Eutatus seguini* (67%, $n = 2$), ñandú (19%, $n = 4$), guanaco (16%, $n = 186$) and pampas deer (9%, $n = 14$). While rodents may mask other taphonomic modifications, especially in cases where the marks are intense, in the AS2 site only a moderate intensity was observed. The size and shape of the rodent marks was not systematically recorded and there are no clear indications of the specific rodent involved in the modification of the bone.

A natural formation process which can lead to bone breakage is weathering. Weathering can contribute to the decay of the cortical surface and in advanced stages led to bone fragmentation. When combined with other modifications, such as chemical deterioration and root etching, a moderate degree of weathering can lead to the eventual fragmentation. All the taxa studied here presented weathering, including *Eutatus seguini* (33%, $n = 1$), pampas deer (21%, $n = 33$), guanaco (18%, $n = 216$) and ñandú (14%, $n = 3$). Most of the specimens presented a weathering stage of 1 (sensu Behrensmeyer, 1978), and only the guanaco presented a weathering stage of 3 or higher.

Geologic abrasion was observed only in guanaco (2%, $n = 18$) and pampas deer (1%, $n = 1$). The abrasion is located on the end of the fracture or on the whole of the fracture surface, with rounded edges, gloss and soft texture. Considering the geological context of the site, the abrasion is aeolian in nature.

Thermal alteration was observed in guanaco (3%, $n = 39$) and pampas deer (8%, $n = 13$). The low frequency of thermal alteration in the bone assemblage suggests that no extensive human induced burning or natural fires occurred at the site. Similarly, the faunal assemblage contains a low number of specimens with cut marks. The majority of the cut marks are found on guanaco bone (2%, $n = 22$). Cut marks were identified on 10 different bone elements and 5 fragments of indeterminate guanaco long bones. Most specimens exhibit only one or two marks on the surface. Based on the morphological characteristics of the marks and their location on the element, three different activities related to processing were identified in guanaco: disarticulation, filleting, and skinning. Only two specimens of pampas deer (1%) and one specimen of ñandú (5%) contained evidence of cut marks.

Carnivore activity was observed in a low percentage of specimens. Different types of carnivore marks were found on the guanaco bone (6%, $n = 69$), most frequently punctures (48%, $n = 33$), furrowing (30%, $n = 21$), pits (16%, $n = 11$), crenulated edges (10%, $n = 7$) and scooping out (9%, $n = 6$). Of the total number of guanaco specimens with carnivore marks, 25% ($n = 28$) correspond to long bones, and 79% ($n = 22$) are located on the epiphyses. No marks were observed in *Eutatus seguini*; and a low percentage were identified in pampas deer (4%, $n = 6$) and ñandú (14%, $n = 3$).

In synthesis, the high fragmentation at the AS2 appears to be the result of a combination of both natural and cultural modifications. Processes such as chemical deterioration (30%, $n = 404$) and root marks (22%, $n = 296$), combined with a moderate degree of weathering

(particularly in the guanaco assemblage) and the extensive human activity (intentional and unintentional bone fractures) has led to the fragmentation of the sample. The cortical surface has also been modified by chemical deposits of manganese (25%, $n = 344$) and calcium carbonate (23%, $n = 316$) which, as stated above, can mask other modifications. Carnivore activity (6%, $n = 78$) and thermal alteration (4%, $n = 52$) appears to have had little effect on the bone assemblage. Perhaps one of the more significant modifications of the bone assemblage not directly identifiable on the cortical surface of the bone is the human burial activity. The burials are found in the Units Z and S and are considered intrusive from the overlying Unit Y (Politis et al., 2016). Their presence indicates that humans acted as a substantial agent in the mixture and fragmentation of previously deposited materials (Gutiérrez and Johnson, 2014).

5. Discussion

5.1. Guanaco

The radiocarbon dates and taphonomic data from the guanaco bone assemblage allow us to recognize at least three processing events at the AS2 site during the Early to Middle Holocene: one around ca. 8400 ^{14}C yrs B.P. (two dates: 8390 ± 410 and 8461 ± 74 yrs B.P.), a second in 7540 ± 80 ^{14}C yrs B.P.; and a third event almost 2 k years later, during the Middle Holocene in 5793 ± 64 ^{14}C yrs B.P. It is difficult to estimate whether guanaco carcasses were processed at the site or transported from other areas. The guanaco anthropic fracture and cut mark evidence suggests that hunter-gatherers fractured long bones of guanaco for obtaining marrow or the manufacture of instruments. The presence of guanaco remains with thermal alteration was minimal and insufficient to conclude that bones were culturally burnt. Furthermore, no hearth was identified at the site to suggest this type of activity.

Integrating the evidence, a model of accumulation (origin of the guanaco assemblage) can be offered; which involves three stages differentiated by the type and intensity of taphonomic modifications. These processes contributed to the accumulation as well as the fragmentation and preservation of the guanaco assemblage and are independent of the radiocarbon dates. First, guanaco bones entered the site principally as a result of human (non-selective) transport. The carcasses were processed by humans, including disarticulation, filleting, and skinning. Second, once discarded, different processes acted on the remains directly and indirectly, contributing to their destruction or preservation, such as the excavation of human burials and unintentional fracturing of bone. Human burial activity would have caused the mixing of materials, and the re-exposure of bone. Scavenging by carnivores of guanaco bones likely occurred once the bones were abandoned by humans. At least nine specimens were identified with both human and carnivore modifications, which suggests that both agents shared this prey. Third, once the remains were buried, they were modified by different natural agents that further contributed to their fragmentation (to a greater degree chemical deterioration and root action), although some taphonomic processes, such as calcium carbonate helped preserve the sample.

5.2. Pampas deer

The evidence of anthropic exploitation of pampas deer is minimal. Only two elements with cut marks (one rib and one humerus) were identified. These are isolated marks which could be related to disarticulation. Like the guanaco, natural alterations on the cortical surface of the pampas deer (chemical deterioration, root marks and weathering) have masked previous modifications and may be contributing in part to the low frequency of cultural marks. Anthropic fractures were detected in a low percentage of specimens. Another indicator of human activity is the thermal alteration, which was recorded -with varying degrees- in 8% of the pampas deer specimens; however, like the burnt guanaco

bones, this modification could have occurred naturally. Radiocarbon dates suggest that part of the remains of this taxon were incorporated into the site during the Early Holocene (7836 ± 69 ^{14}C yrs B.P.). The small sample size relative to the guanaco suggests that the pampas deer was a complementary resource. This is consistent with subsistence models proposed by previous researchers of the Pampas region who suggest this prey was an important resource for hunter-gatherers, but secondary to the guanaco (Martínez and Gutiérrez, 2004; Politis and Salemme, 1990).

As for a model of accumulation; considering its size, the carcasses likely entered the site whole, that is, as part of non-selective transport strategy (Faith and Gordon, 2007). With an average weight between 30 and 40 kg, a complete carcass could be transported to the site. Although the anatomical representation is unequal, as in the case of guanaco, there appears to be differential destruction by natural processes. Once deposited, several of these processes acted on the bone directly and indirectly, such as multiple hunter-gatherer activities (including the excavation of human burials), and the scavenging by carnivores. Natural processes like root etching and chemical deterioration combined with the human activity led to extensive fragmentation and spatial displacement.

5.3. Ñandú

The ñandú at the AS2 site would have provided both meat and egg resources for hunter-gatherers during at least one event in the Early Holocene (7747 ± 56 ^{14}C yrs B.P.). While the regional archaeological and ethnohistorical records describe the importance of rhea in the diet of the Pampas hunter-gatherers, and how it would have served as a secondary/complementary resource (Crivelli Montero et al., 1997; Gutiérrez and Martínez, 2008; Miotti and Salemme, 1999; Salemme and Frontini, 2011); the evidence of human exploitation of this species in the AS2 site is not abundant. Further radiocarbon dating at the site is needed to determine whether this taxon was used in post-Early Holocene times.

As mentioned above, the bone frequency of ñandú is related in part to preservation problems (Cruz, 2009; Cruz and Elkin, 2003; Fernández et al., 2001; Giardina, 2006). So far, only three specimens have been identified with cultural modifications: one with cut marks and three with fractures; insufficient to discuss detailed processing activities (i.e., primary, or secondary). Furthermore, some ñandú specimens exhibit carnivore marks, suggesting variable agents modifying this taxon. It appears that at least part the ñandú remains entered the site as the result of human transport (non-selective) and, in similar or higher frequency, by carnivores. Once deposited, different processes modified the remains which caused the fragmentation and spatial displacement of the bone, such as human burial activities, root action, and rodent marks.

5.4. *Eutatus seguini*

With only three bone specimens of *Eutatus seguini*, any discussion of hunter-gatherer subsistence strategies is limited. While all three specimens were recovered in the lower stratigraphic units, and may represent a part of the Pleistocene faunal assemblage (see Politis et al., 2016); no direct evidence of cultural modification was recorded. The presence and frequency of processing marks depends on factors such as time, location, the state of the bone –fresh or dry–, the ability of the butcher, among other variables (Frison, 1986; Haynes, 1983; Johnson, 1985). If the carcasses were scavenged, then not only were they stiffened, but over time the bones greasiness and ability to helically fracture would have been reduced. Consequently, a stiffened carcass will result in more cut marks or require a skillful butcher to avoid leaving marks (Haynes and Krasinski, 2010; Johnson, 2007; Johnson and Bement, 2009; Potter, 2005; Shipman and Rose, 1983). An important subject matter of the *Eutatus seguini* in the AS2 site is the Early Holocene date

(7388 ± 74 ^{14}C yrs B.P.), which is consistent with previously stated models which suggest that humans co-existed with extinct large sized mammals until the end of the Early Holocene (Gutiérrez et al., 2010; Politis and Messineo, 2008). A similar date at the Paso Otero 4 site, located 130 km east of AS2, contains *Eutatus seguini* bone in sediment dated 7729 ± 48 ^{14}C yrs B.P. (Álvarez et al., 2013).

With respect to a model of accumulation of *Eutatus seguini* in the AS2 site, with only two bone specimens and one fragment of scute dermal bone, it is difficult to determine the nature of this taxon. Once the bones were deposited in the assemblage they suffered similar modifications as the other taxa discussed above, including root action and rodent marks, which combined with human activities (i.e., burials) resulted in the fragmentation of the bone elements.

6. Conclusion

In the advent of the extinction of all megamammals and most large sized mammals, the subsistence pattern during the Early Holocene shifted to smaller sized prey. Based on the data from the AS2 site, this shift appears to have been gradual, as the subsistence strategy remained a generalist regional economy which included different sized prey (Martínez and Gutiérrez, 2004). The AS2 site contains four different taxa of various body sizes (large and medium) dated between ca. 8461 and 7388 ^{14}C yrs B.P. Furthermore, if we include those species not analyzed in this paper which were identified in the site but are lacking radiocarbon dates, such as the plains vizcacha and hairy armadillo, we can further argue the generalist strategy. However, these taxa (including *Eutatus seguini*) lack clear evidence of human consumption, and their presence alone is not enough to prove they were part of the hunter-gatherers diet. Until further evidence is provided, these species cannot be included in the discussion of processing activities in the AS2 site. The most concrete evidence of faunal processing activities in the AS2 site comes from the guanaco and pampas deer. Although it is difficult to determine whether all stages of processing of these taxa occurred at the site, or if the carcasses were transported from another location, the presence of numerous bones with anthropic fractures and cut marks confirms that hunter-gatherers fractured bones for marrow or the manufacture of instruments (Gutiérrez and Johnson, 2014; Salemme, 2014). The Early Holocene faunal assemblage from AS2 is comparable to other sites dated to this time period in the Pampas region; specifically, the presence of guanaco, *Eutatus seguini*, and ñandú. While the pampas deer is an abundant taxon in the regional archaeological record (Martínez et al., 2016; Martínez and Gutiérrez, 2004), the radiocarbon date at the AS2 site confirms that this species was a prey choice during the Early Holocene.

Finally, during the Middle Holocene, at the regional level, hunter-gatherers are characterized by a specialized regional economy, based principally in the hunting of guanaco (Gutiérrez and Martínez, 2008; Martínez and Gutiérrez, 2004). While only one radiocarbon date for guanaco was obtained from the AS2 assemblage for this period (5793 ± 64 ^{14}C yrs B.P.), the evidence from site is consistent with this subsistence model. Indirect evidence from the site, including the isotopic studies of selected human remains dated to the Early and Middle Holocene (7805 ± 85 to 4487 ± 45 ^{14}C yrs B.P.) indicate the consumption of terrestrial herbivores; which could include guanaco and pampas deer, and some C_4 plants and marine foods (Politis et al., 2009). This data supports a specialized economy in medium sized mammals (i.e., guanaco), but also suggests a generalized subsistence with complementary resources such as pampas deer, plants, and coastal resources. To provide a more comprehensive representation of subsistence strategies during the Early to Middle Holocene, radiocarbon dating of smaller prey such as rodents, small birds and armadillos, combined with isotopic studies, is critical for future research designs.

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